Sarah Spiekermann-Hoff and Jana Korunovska

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Sarah Spiekermann
Institute for Management Information Systems
Vienna University of Economics and Business (WU Vienna)
Welthandelsplatz 1
1020 Vienna
Austria
Tel: +43 1 313365460
e-mail: sspieker@wu.ac.at

Jana Korunovska
Institute for Management Information Systems
Vienna University of Economics and Business (WU Vienna)
Welthandelsplatz 1
1020 Vienna
Austria
Tel: +43 1 313364428
e-mail: jana.korunovska@wu.ac.at

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ABSTRACT

In this paper, we describe two experiments that show the powerful influence of interface complexity and entropy on online information sharing behaviour. 134 participants were asked to do a creativity test and answer six open questions against three different screen backgrounds of increasing complexity. Our data shows that, as an interface becomes more complex and has more entropy users refer less to themselves and show less information sharing breadth. However, their verbal creativity and information sharing depth do not suffer in the same way. Instead, an inverse U-shaped relationship between interface complexity and creativity as well as information sharing depth can be observed: Users become more creative and thoughtful until a certain tipping-point of interface complexity is reached. At that point, creativity and thinking suffer, leading to significantly less disclosure. This result challenges the general HCI assumption that simplicity is always best for computers' interface design, as users' creativity and information sharing depth initially increases with more interface complexity. Our results suggest that the Yerkes-Dodson Law may be a key theory underlying online creativity and depth of online disclosures.

Author Keywords: Online Information Sharing, Disclosure, Interface Complexity, Interface Design, Entropy, Privacy

1. Introduction

As more and more work is performed online, designing the right interface for an online task has become an important economic necessity. Common wisdom for the design of Web interfaces is that they should be as ordered and simple as possible (Te'eni et al., 2007). Furthermore, they should be structured according to the Gestalt principles of closeness, closure and similarity (Nielsen, 1993). If interfaces are too complex or chaotic, it is generally assumed that they undermine a user's creativity and performance online. For this reason, standards have evolved for color schemes and information ordering on websites. In addition, academics and practitioners have worked to minimize visual complexity and clutter on websites (Ware, 2004).

When investigating visual complexity, researchers in the field of human computer interaction often pursue one of two research goals: One is to understand visual complexity conceptually and to find ways to measure it objectively (Rosenholtz et al., 2007). Researchers who pursue this goal define the complexity of an interface as the degree of perceivable structure it contains (Oliva et al., 2004).

Another research community is interested in how the complexity of a given interface affects key psychological performance indicators. For example, Ware (Ware, 2004) shows how excess or disorganized display items decrease object recognition and impair visual search performance. Miller (Miller, 1956) describes how more than seven items on a screen stretch or exceed the limits of short-term memory. The literature on information overload suggests that the complexity of information leads to limited information search and retrieval strategies as well as a loss of control and communication breakdown (Eppler and Mengis, 2004).

Despite this ongoing interest of researchers in interface complexity and its effects, no study has to our knowledge investigated the influence of interface complexity on information sharing behaviour. This gap is surprising because information sharing behaviour is at the heart of the digital economy. Website operators want to motivate as much information sharing behaviour on their sites as possible; when users share more information, operators understand them better and can send them personalized advertisements that fit their online disclosures. Presenting personalized advertisements to users is currently one of the main business models on the Internet (Anderson, 2009). Moreover, online platforms (such as Facebook) want to accumulate rich user-generated content because they hope that the information investment made by users will make them more loyal and discourage them from switching to other sites (Varian and Shapiro, 1999). Hence, online operators must be highly interested in interface characteristics that drive information sharing behaviour. Without information sharing, the Web as we know it simply could not exist.

Despite the importance of information sharing, which we also refer to in this article as “disclosure”, insights into the dynamics of this behaviour online are only beginning to be seen. Communication researchers have looked at offline social dynamics (such as social expectations, gender models, group behaviour, etc.) and their relevance for online communications (Moon, 2000, Reeves and Nass, 1996, Huberman et al., 2004). After communication scholars, e-privacy scholars have most actively expanded knowledge about information sharing behaviour online. They research why people express concerns about their privacy (Smith et al., 1996) but then reveal so much about themselves. This phenomenon is called the ‘privacy paradox’ (Brandimarte et al., 2010). One influential group of e-privacy scholars has attempted to transfer the core concepts of behavioural economics to privacy. This group begins with the assumption that people run through a rational ‘privacy calculus’ when they share information online (Dinev and Hart, 2006, Acquisti and Grossklags, 2005). However, in their experiments, these researchers show that people rarely decide what and how much they disclose in a rational way. The researchers find that learned heuristics, values and frames influence disclosure behaviour (Kahneman and Tversky, 2000, John et al., 2011, Brandimarte et al., 2010). For example, they have shown that people feel more comfortable with disclosing unethical behaviour in an unprofessional website context than in a professional one (John et al., 2011).

What has not been studied are context variables that drive information sharing at a more intuitive, subconscious level and that are not bound to learned heuristics, values or frames. In particular, information complexity of a website and its level of entropy may be important drivers of how much and what users disclose. Interface complexity is the degree of perceived structure that an interface has. Repetitive and uniform structures (Heaps and Handel, 1999), regularities and perceptional grouping (van der Helm, 2000) and limited variety in the visual stimulus (Heylighen, 1997) have all been identified as traits of an image that reduce complexity. Some scholars look at information density as a particular kind of complexity that is influenced by the number of visible objects on a screen and the number of vertices (Woodruff et al., 1998). Others use the construct of entropy to measure visual clutter in an interface. In simple terms, entropy can be defined as the amount of disorder or randomness in a system (Encyclopaedia Britannica Micropaedia, 2007) or as the uncertainty inherent in an incoming message (Shannon, 1948, Shannon and Weaver, 1949). Scholars argue that greater variability in an image makes that image less predictable for a user and requires the user to process more information (Rosenholtz et al., 2007). As a result, higher information complexity in a static image is also associated with higher entropy. Figures 1a and 1b demonstrate two computer interfaces with exactly the same bit rate. However, the interface in figure 1a has a low algorithmic complexity or low entropy, while the interface in figure 1b has a high algorithmic complexity and hence a higher entropy. When interfaces include movement, then the more random or 'uncertain' these movements are, the more entropy does the interface have.

Since websites today regularly include moving elements and are often cluttered with advertisements, it is interesting to ask how these design elements impact information sharing behaviour. Our work is, however, not driven only by this practical question, but also inspired by Lawrence Wiener's work on cybernetics. Wiener postulated that entropy in the environment and human reactions to this entropy are related. He wrote that *"…the physical functioning of the living individual…attempts to control entropy through feedback"* (Wiener, 1950). We were interested to see how this relationship could play out at the human computer interface. Confronting computer users with higher degrees of interface entropy, we wanted to see how they would try to control this entropy and adjust their feedback, operationalizing "feedback" as information sharing behaviour.

We set up two experiments to study the relationship between visual complexity, entropy and users' information sharing behaviour. After an introductory section about our research hypotheses and related work (section 2), section 3 describes the first experiment, where subjects completed a creativity and disclosure exercise against the background of either a simple black and white display or a cluttered display. In section 4, we provide more details about the concept of entropy and present a second experiment where we varied the level of entropy in the interface. Our experimental findings suggest that human online behaviour is very sensitive to the most subtle interface variations. In fact we find that, in line with Wiener's thoughts, entropy may influence how human beings share information online.

2. Related Research and Hypotheses

Our work aims to investigate the implications of interface complexity for information sharing behaviour. Information sharing behaviour is driven by two dimensions: (1) Users' *ability* to share information and (2) users' *willingness* to disclose. Users' ability to share information is commonly measured with the help of verbal creativity tests (Schoppe, 1975). Willingness to disclose, in contrast, is captured as the breadth and depth of what is said or written (Moon, 2000, Derlega et al., 1993).

How might interface complexity influence information sharing behaviour? Several observations from the field of psychology suggest that information sharing behaviour should suffer in the face of complex information environments because higher levels of entropy or information complexity degrade performance. Experiments of Hick (Hick, 1952) and Hymans (Hyman, 1953) have shown that higher entropy levels or uncertainty in a light stimulus lead to longer reaction times (Hick, 1952, Hyman, 1953). They argue that entropy causes cognitive load through more information processing. As a consequence, people become slower at the tasks they perform.

Marketing studies on information structure and choice behaviour provide similar reasoning. Lurie (Lurie, 2004) has shown that increasing the amount of information leads to increased information processing and causes consumer choices to suffer. Consumers' memory of focal brands suffers if advertisements add too much complexity to a site (Ha, 1996). Worse performance in cognitively complex tasks is often explained by the limited capacity theory of attention (Kahneman, 1973): Cognitive capacity is limited and must be shared between all running tasks. As the complexity of one processing task increases, the performance of other tasks suffers.

Because reaction times, decision making and memory are all affected by information complexity, we expect that varying levels of interface complexity also affect performance at an information-sharing task. In line with Rosenholtz et al. (Rosenholtz et al., 2007) we argue that unordered bits of information in an interface make users less certain that they can capture all information. In addition, greater numbers of unordered bits or even uncertain movements in an interface increase the cognitive effort users require for processing. In other words, users are so busy processing a highly complex interface that fewer resources are left for an information-sharing task. In line with limited-capacity theory, we hypothesize that humans' *ability* to share information (verbal creativity) should be affected by an interface's complexity.

H1: Verbal creativity is higher with simple interfaces than complex interfaces.

Besides verbal creativity, users' willingness to disclose information will drive information sharing behaviour: Users must be motivated to share information. Yet, complex interfaces could cause such frustration that users are reluctant to disclose. Several areas of research lend support to this argument. For example, marketing researchers showed that advertisement clutter is perceived as intrusive and leads consumers to develop negative attitudes towards advertisements. When consumers are irritated by advertisements, they display cognitive as well as behavioural avoidance strategies (Edwards et al., 2002). Other studies in the domain of information overload have shown that information complexity reduces motivation (Baldacchino et al., 2002) and causes stress and anxiety among users (Jacoby, 1984, Wurman, 2001). Generally, users are annoyed by websites that contain a lot of distracting content, and users spend less time and effort on them. Against this background, we question whether users in complex interface settings can be as motivated and emotionally ready to disclose. We therefore hypothesize:

H2: Users share more information with simple interfaces than complex interfaces.

3. Experiment 1: Information sharing behaviour with simple and complex interfaces

Experiment 1 investigated whether interface complexity influences users' online creativity and willingness to share information with the interface. Between subjects, we manipulated the complexity of the website interface: In one condition, participants saw a simple black and white interface with low entropy. Against this background, they were asked to do a creativity test and answer 6 open-ended questions. In the second condition, participants viewed a complex cluttered interface and were asked to do the exactly the same information sharing tasks. We predicted that users' creativity and disclosure would suffer in the face of the complex interface.

3.1 Method

76 participants were invited to an Austrian university computer lab to pilot test an ostensibly novel online creativity assessment tool. In exchange for their participation, they received € 8 in compensation and feedback on their individual creativity scores. We invited only German native speakers to the experiment since information sharing behaviour may be impacted by language skills.

Typically, 15 to 30 participants were tested simultaneously per session. Cubicles sheltered each desk so that participants could not see each other. To prevent confounding effects caused by screen size or configuration, all screens were identical in size.

When participants registered for the creativity test, they were randomly assigned to one of two interface background conditions (figures 1a and 1b). The backgrounds differed in their algorithmic complexity. Participants completed an online tutorial on the connection between thermodynamic entropy and information (Dow, 2010), where they saw examples of low and high entropy images. In condition 1 – the simple background condition - the background consisted of 53.754 bits ordered in two black and white surface areas (figure 1a). In condition 2 – the complex condition – the interface background had the same number of bits, but the bits were cluttered across the interface without any apparent order (figure 1b). At the top of the screen, we placed the question participants needed to answer. In the middle of the screen they could type their answer into a textbox. When subjects moved to the next question by clicking on an icon called "next" in the lower part of the interface, the background image turned clockwise 90° to the right to display the following question. We added this movement to both conditions to force participants to readjust to the background for each new question. The reason we used an *artificial* background in this experiment instead of a normal Web interface is that we wanted to avoid any familiarity with the images (such as a landscape). Because familiarity can influence the perception of complexity (Oliva et al., 2004, Heylighen, 1997), it could have introduced a confounding variable in our data.

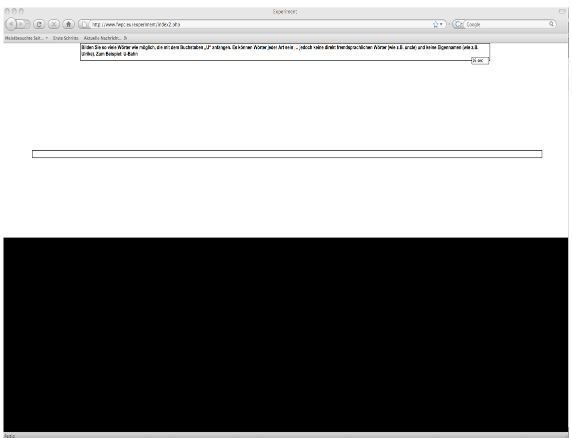


Figure 1a. Condition 1, Simple

(Low Interface Complexity, Low Entropy)

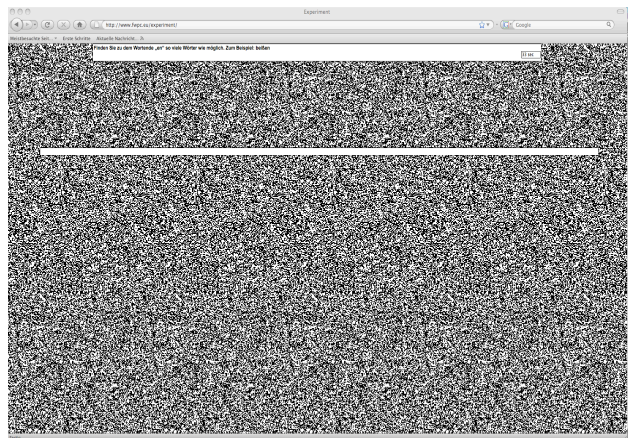


Figure 1b. Condition 2, Complex

(High Interface Complexity, High Entropy)

The first four items were taken from Schoppe's standardized verbal creativity test instrument (Schoppe, 1975). The test questions are listed in appendix 1. Schoppe's creativity test asks subjects to come up with as many ideas as possible in a fixed time frame. For example, the test gives subjects 75 seconds to come up with as many words as possible that start with an 'A'. The next three items were self-developed, impersonal open-ended neutral questions about the computer's interface, the general importance of creativity in society and whether the Internet should forget. Finally, three more highly intimate items asked for personal information about an embarrassing situation the participant had encountered, a situation that he or she had been in and would like to forget and a personal cause he or she thinks is worth fighting for. For all of these self-developed disclosure items, participants were informed that they could take their time to answer them. They typed their answers into a text box located in the center of the screen. The questions that we used are included in appendix 1.

After participants completed the task, they filled out an online questionnaire regarding their experience during the experiment. Participants were first asked for their emotions (employing the SAM Test instrument for both valence and arousal (Lang, 1980)). They were then asked about the cognitive strain they perceived during the experiment (Manning, 1998). Furthermore, participants filled in a debriefing questionnaire containing questions on the perceived interface order (manipulation check) and socio-demographics. Finally, participants filled in items taken from a standard verbal intelligence test (Aster et al., 2006) and questions on privacy concerns (Buchanan et al., 2007). These questions controlled for an equal distribution of these known predictors of information sharing behaviour across conditions.

3.2. Results

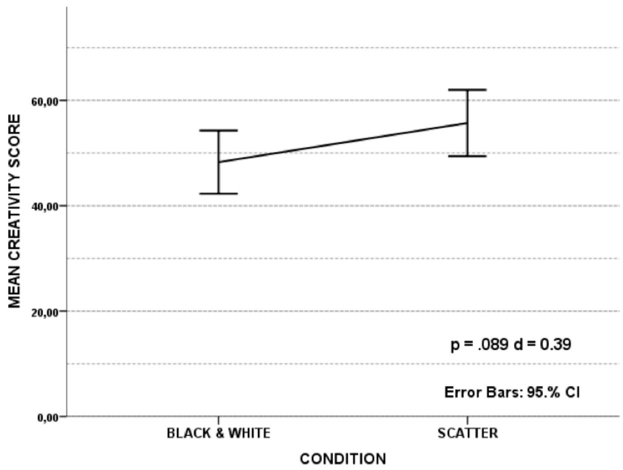
Of the 76 participants, 37 (48.7%) were in the simple black and white condition 1. 39 (51.3%) were in the complex clutter condition 2.

Creativity was analyzed in line with the test instrument's instructions (Schoppe, 1975): the *sum* of the total number of ideas listed by a subject in response to the first four creativity items formed a creativity score. Disclosure was analyzed based on the responses to the six open-ended questions. Disclosure is typically measured in terms of depth (quality) and breadth (quantity) (Moon, 2000, Derlega et al., 1993). Depth of disclosure is operationalized as the number of thoughts that users share, while breadth is reflected in the number of words. We also refer to number of words as "verbosity". The number of thoughts was counted by two independent coders (intercoder reliability equalling $r = .976$). The results we found were surprising and partly not in line with our hypotheses (see figures 2a and 2b).

First, we found that the creativity score *increased* significantly in the light of more complexity ($M_{b\&w}$ = 48.27, $SE_{b\&w}$= 2.96 vs. $M_{scatter}$ = 55.69, $SE_{scatter}$= 3.11; $t(74)$= -1.73, p (one-tailed) < .05, effect size d = 0.40), as did the average number of thoughts raised in the disclosure section ($M_{b\&w}$ = 2.99, $SE_{b\&w}$ =.19 vs. $M_{scatter}$ = 3.87, $SE_{scatter}$ = .29, $t(74)$ = -2.53, p (one-tailed) < .01, effect size d = 0.57). Thus, both of our hypotheses were rejected. However, a small effect could be observed in line with hypothesis 2: the average number of words or depth of information sharing decreased as interface complexity increased ($M_{b\&w}$=87.80, $SE_{b\&w}$ = 10.54 vs. $M_{scatter}$=75.14, $SE_{scatter}$ = 7.65, $t(74)$ = .98 p > .05, effect size d=0.22).

Further analysis of the data showed distinct disclosure behaviours for neutral and intimate questions. Figure 2c demonstrates that the breadth of disclosure (average number of words) suffered much more when participants responded to intimate items (neutral disclosure: $M_{b\&w}$=81.06, $SE_{b\&w}$ = 8.05 vs. $M_{scatter}$= 79.18, $SE_{scatter}$ = 8.06, $t(74)_{b\&w}$ = .17. p > .05, effect size d=0.04; personal disclosure: $M_{b\&w}$=94.54, $SE_{b\&w}$ = 13.98 vs. $M_{scatter}$= 71.10, $SE_{scatter}$ = 7.69, $t(74)_{b\&w}$ = 1.49 p > .05, effect size d=0.34; $MD_{neutral}$= 1.88 $MD_{personal}$= 23.43). Furthermore, we counted the number of self-references that subjects used (i.e. I, me, mine, myself, and so on). Here, the trend towards becoming less personal or less self-referencing in the cluttered interface context became even clearer, with a medium effect size ($M_{b\&w}$= 5.43, $SE_{b\&w}$ = .89 vs. $M_{scatter}$= 3.07, $SE_{scatter}$ = .49, $t(74)$ = 1.69 p (one.-tailed) < .05, effect size d = 0.39) (see Figure 2c).

The manipulation check confirmed that the complex cluttered interface was perceived as more chaotic ($M_{b\&w}$ = 2.36, $SE_{b\&w}$ = .39 vs. $M_{scatter}$= 7.15, $SE_{scatter}$ = .35, $t(73)$ = -9.19, p < .001). The post-study questionnaire also confirmed that verbal intelligence was equally distributed across groups ($M_{b\&w}$ = 2.48, $SE_{b\&w}$ = .20 vs. $M_{scatter}$= 2.73, $SE_{scatter}$ = .22, $t(47)$ = -.84, p > .05), as were privacy concerns ($M_{b\&w}$ = 16.82, $SE_{b\&w}$ = .69 vs. $M_{scatter}$= 16.91, $SE_{scatter}$ = .76, $t(48)$ = -.09, p>0.5).



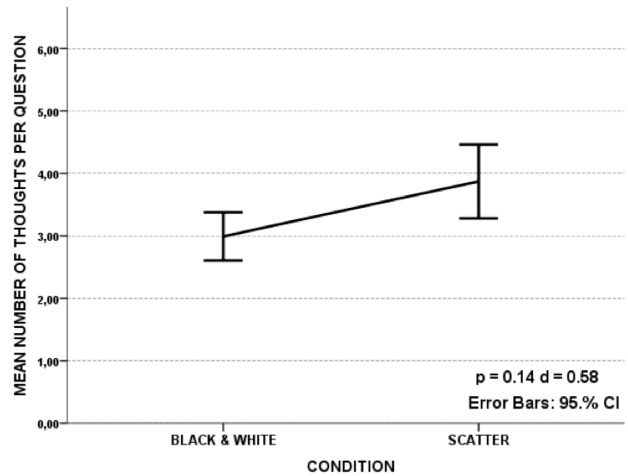
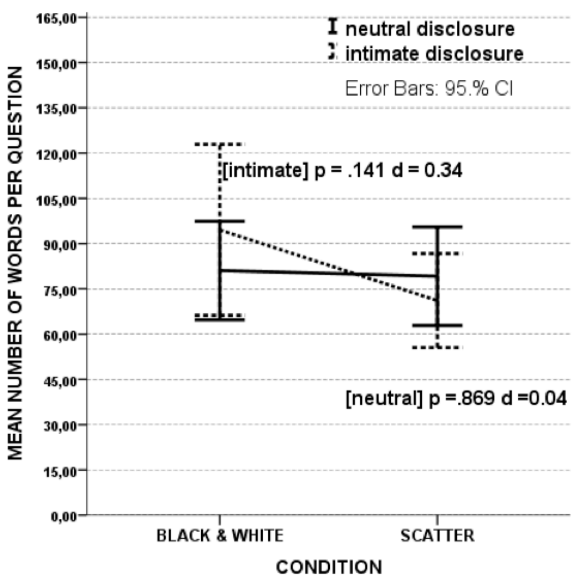


Figure 2a. Creativity Increases with Interface Complexity

Figure 2b: Information Sharing Depth Increases with Interface Complexity



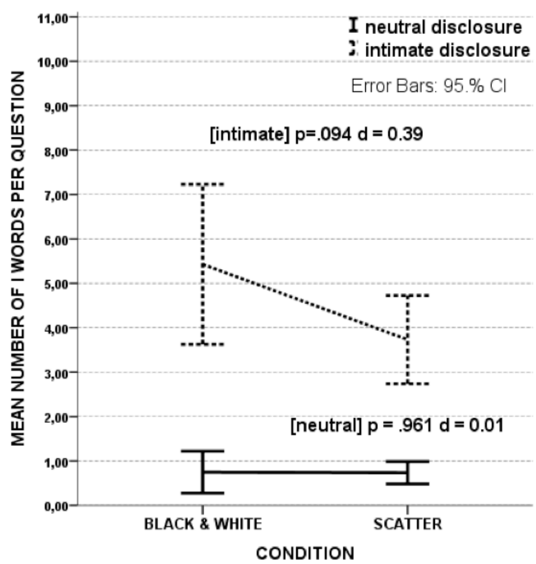


Figure 2c. Intimate Information Sharing Breadth Decreases with Interface Complexity

Figure 2d. Intimate Self-References Decrease with Interface Complexity

3.3. Discussion

The results of this first experiment clearly show that the widespread acceptance of simple interfaces is a double-edged sword: It seems to be the better choice in contexts where users are asked personal questions and talk about intimate issues. Our data shows that subjects were more open in their communication with a simple interface, used more words, and wrote more that was personal in nature. However, when the goal is to foster creativity and thought, our data suggests – against expectations – that a complex interface works better. But is this really so? Would these observations hold true if we increased complexity even further? Can these observations be explained?

The emotional valence as measured by the SAM test instrument (Lang, 1980) showed that subjects were significantly more positive emotionally in the simple black and white condition ($M_{b\&w}$= 6.58, $SE_{b\&w}$ = .28 vs. $M_{scatter}$= 5.97, $SE_{scatter}$ = .24, $t(73)$ =1.68 p(one-tailed) <.05, effect size d = 0.39). This finding suggests that users are more motivated to participate with a simple design. This may explain why they write more and become more personal with a simple background.

But the finding that users became more creative and had more thoughts in the complex interface condition cannot be explained by any of the covariates we measured. However, old studies on cognition and behaviour have shown that people perform better in the face of more demand: in 1908, Yerkes and Dodson discovered that cognitive performance (in their case, memory) is positively related to the level of strain and activation (Yerkes and Dodson, 1908). And as human strain increases, attention narrows. This narrowing of attention helps people focus (Kahneman, 1973). We did measure the self-reported level of cognitive strain as a sum of self-reported stress and energy levels. Our result reflected the expected direction but was not statistically significant ($M_{b\&W}$ = 7.78, $SE_{b\&w}$=.61, $M_{scatter}$= 7.82, $SE_{scatter}$=.55, p = .956, effect size d=0.01). As it is well known that self-reported post hoc measurements of stress are often fragile, we believe that the Yerkes-Dodson Law (Yerkes and Dodson, 1908) could apply to our results. If it did, a further increase in interface complexity and therefore arousal should at some point lead to an inflection of the performance curve for creativity and information sharing depth. This inflection would produce an inverse U-shaped progression. We therefore ran another experimental condition in which we further increased the interface's complexity.

4. Experiment 2: Investigating Yerkes-Dodson law as a way to explain online information sharing behaviour

Based on the findings from experiment 1 and the suggestion that the Yerkes-Dodson phenomenon might be at work, we now hypothesized an inverse U-shape for creativity and the number of neutral thoughts. That is, if our new high-entropy stimulus succeeded in raising the participant's arousal above a tolerable threshold, that participant's creativity and number of thoughts should suffer. Similar to our setting, authors in the field of marketing have investigated the effects of website animation on users' performance. They confirmed an inverse U-shaped relationship between the degree of banner animation and users' ability to recall the advertisements displayed (Yoo and Kim, 2005). We therefore hypothesized:

H3: As interface complexity increases, creativity and information sharing depth follow an inverse U-shape.

In addition, we discovered in experiment 1 that neutral disclosures do not follow the same pattern as intimate disclosures. Although users have similar levels of verbosity and make similar numbers of self-references in response to neutral questions, their willingness to disclose intimately suffers as interface complexity increases. From experiment 1, it seems that users were emotionally unnerved by higher interface complexity, which might have reduced their willingness to talk about personal issues and refer to themselves. Believing that they needed to perform well in an ostensible creativity test, they seem to have continued to disclose on the neutral items. However, their real motivation was revealed by the degree of personal intimacy in their responses. If negative emotion caused this behaviour, as our emotional valence results from experiment 1 suggest, then a further increase in interface complexity should lead to even more negative feelings in experiment 2 and even fewer intimate disclosures. We hypothesized:

H4: More interface complexity leads to less information sharing breadth and fewer self-references in response to intimate questions.

4.1. Method

To test our hypotheses, 58 subjects were invited to the lab to take the ostensible creativity test under the same conditions as the first experiment. 62.1% of them were male. Again, the majority were students (80.6%), with a mean age of 24.4 years, and all invited subjects were native German speakers.

Subjects saw another version of the interface's background (condition 3). Our goal was to present them with a background that would be perceived as even more complex and induce even higher levels of arousal and cognitive load than the one used in condition 2 of experiment 1.

To increase interface complexity, we added uncertain movement to the cluttered version of the interface depicted in figure 1b. With this uncertain movement, we increased the entropy of the interface. As outlined above, entropy can be defined as "the disorder, or randomness, of a system" (Encyclopaedia Britannica Micropaedia, 2007) and has been formalized in information theory by (Shannon, 1948) as follows:

$$H(X) = -\sum_{i=1}^{n} p_i(x_i) * \log_b p(x_i)$$

where

H = entropy, the level of uncertainty of a state

n = the total number of potential states

$p(x_i)$ = the assessed probability that a particular state will incur

b = the dimensionality of the problem

The movement we added to the interface made users more uncertain as to what the background would look like from one moment to the next. This is, because the screen did not rotate clockwise once between questions, but instead every 15 milliseconds, 200 pixels moved on the screen. Every pixel could move randomly and with equal probability in one of four directions (up, down, left or right). As a result, a pattern was not discernable.

Here, n = the number of possible screens following a previous screen, which equals the number of possible positions the pixels could have after one iteration (200 x 4 = 800). And p = the probability that a specific screen will appear (which was 1/800). In the static scatter manipulation, the background picture's entropy was effectively 0 because it involved no movement and thus no uncertainty. In the new manipulation, the entropy (H) equalled 9.64 (using a base of 2 for the logarithm). Against this background, we argue that the additional condition in experiment 2 increased the complexity of the interface, at least in terms of entropy.

4.2. Results

Again, we analysed the development of creativity and total number of thoughts. Intercoder reliability of thoughts expressed was r =.989. In line with hypothesis 3, we found that cognitive performance suffered when movement was added to the cluttered interface background. Figures 3a and 3b display how both creativity ($F(2,131) = 2.78$, $p = .065$, $f = 0.20$) and number of thoughts ($F(2,131) = 5.10$, $p < .01$, $f = 0.27$) follow the predicted inverse U-shape as the interface increased in complexity. But this curve development is significant only for the number of thoughts. Both curves have a medium effect size difference between the conditions. Post-hoc tests reveal differences between the simple black and white and the complex cluttered interfaces (experiment 1) and between the cluttered and the cluttered with movement conditions (experiment 2). The increase in cognitive strain due to movement is higher than its increase due to scatter ($M_{scatter} = 7.82$, $M_{scatter + movement} = 8.37$, $SE = .41$). However, again this increase was not statistically significant.

As expected, the average number of words decreased for both neutral and intimate disclosures (figure 3c). The decrease was significant for the intimate question context, with an almost medium effect size ($F_{personal}(2,131) = 3.77$, $p_{personal} < .05$, $f_{personal}=0.23$). The number of self-references also decreased significantly in the intimate question context as the interface became more complex ($F_{personal}($ $(2,131) = 4.47$, $p_{personal} < .05$, $f_{personal}=0.26$)..

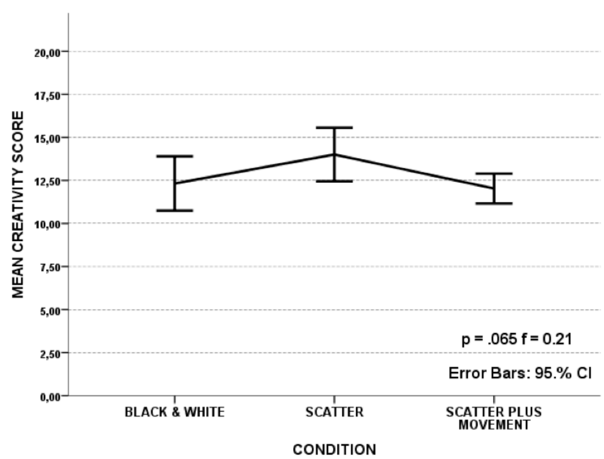


Figure 3a. Creativity U-shaped with

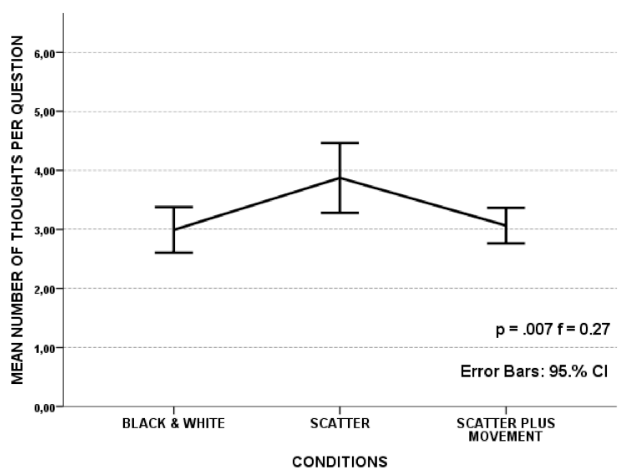
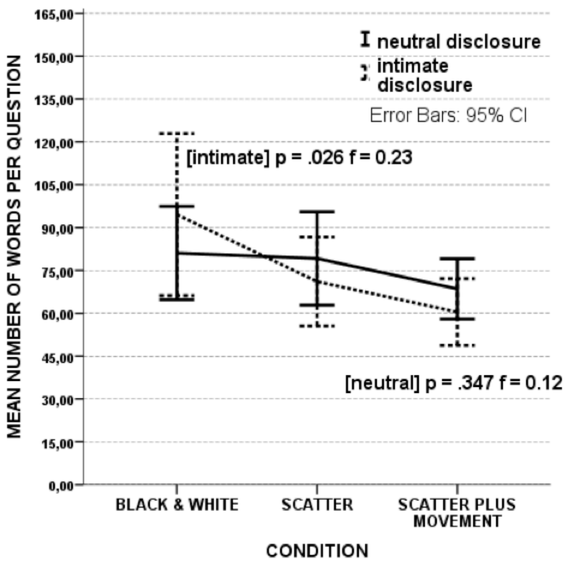


Figure 3b: Information Sharing Depth U-

Interface Complexity

shaped with Interface Complexity



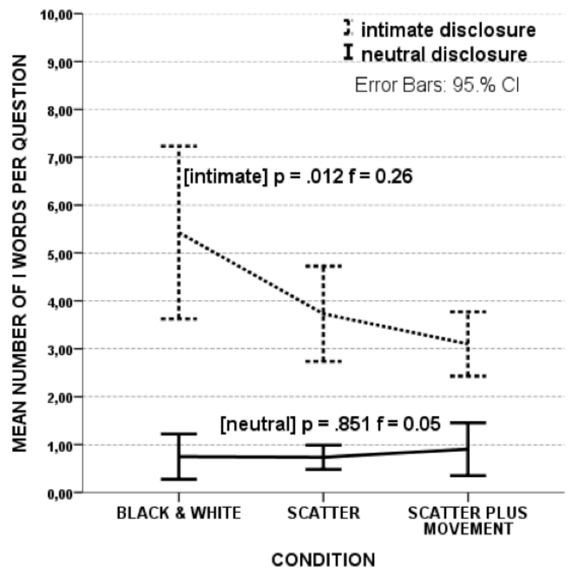


Figure 3c. Intimate Information Sharing Breadth Decreases with Interface Complexity

Figure 3d. Intimate Self-References Decrease with Interface Complexity

4.3. Discussion

The data collected in condition 3 is in line with our finding from the first experiment that intimate and neutral disclosures are different in the face of varying interface complexity. While a neutral information-sharing context is not affected by increased interface complexity, an intimate information-sharing context is: users' number of self-references decreases significantly and their verbosity is regressive. Thus, we find support for hypothesis 4. No support could be found for the influence of emotional valence, which could have explained these findings on intimate verbosity and self-reference decline.

We also find some evidence for hypothesis 3. Both creativity and information sharing depth follow the predicted inverse U-shape. However, this curve progression is significant only for information sharing depth, and hence hypothesis 3 can be only partially accepted.

5. General Discussion and Conclusion

The two experiments presented in this article follow a very simple set-up. Users were asked ten questions while using three different interface backgrounds: simple black and white, cluttered and cluttered with movement. The resulting differences in information sharing behaviour are considerable: Our data clearly demonstrate that interface complexity reduces users' propensity to talk about themselves and to refer to themselves. However, it also shows that complexity has such a negative effect only in the context of intimate disclosure. When users were asked to report on embarrassing situations or events they would want to forget, they became much less willing to do so as interface complexity increased. They also reference themselves less, using less I-words. In neutral disclosure contexts, in contrast, complexity of the background does not affect information sharing breadth or references to the self. We are not aware of any research to date that would have suggested that neutral and intimate exchange follows such different dynamics and are so sensitive to interface design. The finding has practical implications because it suggests that websites engaging users in intimate communication (such as health sites or blogging sites) should use very simple and low entropy user interfaces if they want users to be engaged and talk about themselves.

Another result of our work is that interface complexity is not necessarily bad for information sharing breadth or creativity. In contrast, creativity and information sharing breadth seem to be animated by more interface complexity, at least up to a tipping point. If operators want their users to be creative and thoughtful, a certain degree of complexity could thus be helpful. For example, when comparing the search engines Bing and Google, Bing might get more creative queries because its design is more complex. But as the U-shaped relationship between creativity and complexity shows, operators must be careful about how complex sites become: at a tipping point, users' thoughtfulness and creativity decrease.

We do recognize the limitations of theoretically explaining our results by using the levels of strain and emotional valence. Even though the complexity of the stimuli interfaces increased demonstrably and mathematically, a statistically significant increase in cognitive strain would have allowed us to reliably say that the Yerkes-Dodson law was at work in this context. Nevertheless, the observations summarized in figures 3a – 3d should still interest researchers who want to understand the psychological underpinnings of online work. Furthermore, we believe that better ways to measure cognitive strain and emotion in this context would reinforce our arguments for the influence of these factors.

Besides improved control over users' psychological and physiological reactions to interface complexity, we see two further avenues of research as particularly promising: One is the study of the exact moment where creativity and thoughtfulness start to suffer from too much interface complexity. For this avenue, we would need experiments that reconfirm the exact inverse U-shaped progression of performance. Ideally, these experiments would employ real-world scenes with different degrees of clutter. These degrees of clutter could be measured by using something like sub-band entropy (Rosenholtz et al., 2007). To confirm U-shaped creativity and disclosure reactions to clutter, a standard-point of creativity inflection could potentially be isolated.

Another interesting avenue of research could be to determine how exactly movement adds to interface complexity. Movement has become an integral (and annoying) part of many modern Web interfaces. For this reason, we have started to think about using an entropy measure for pixel movements. However, no scholars have yet attempted to develop entropy measures for website animations or embedded video.

Once we know how to operationalize interface complexity with movement through entropy measures, we can re-run the kind of experiment presented here and replace the artificial background structure with image and video backgrounds that are closer to the kinds that are found on most websites today.

Finally, Wiener's idea of humans' desire to control entropy through feedback may be revisited. Our data suggests that users react to increased entropy in computer interfaces: They talk significantly less about themselves, and their verbosity is curbed. So could it be argued that people generally meet disorder and uncertainty in their computer environments with a personal retreat? Might they meet an increase in entropy with a strategy to reduce it again (on another level)? The idea that human life is marked by a constant reaction to entropy is at the heart of Wiener's cybernetic theory. He wrote: "If we wish to use the word 'life' to cover all phenomena which locally swim upstream against the current stream of increasing entropy, we are at liberty to do so" [p.32 in 36]. If our research provides evidence to support his theory, we are proud to have done so and encourage the research community to pursue it further.

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Appendix 1

Questions used in the two experiments. The first four items are a translated version of Schoppe's creativity test (Schoppe, 1975). The other items were self-developed.

Verbal Creativity	
Question 1	"Come up with as many words as possible that start with the letter "A". These can be words of any kind…however, not including person names or foreign words. You have 90 seconds to answer."
Question 2	Find as many words as possible that end with the syllable "ein". You have 90 seconds to answer."
Question 3	Please think of as many unusual usage categories as possible for a common object that we call out to you. The object is a "simple cord". You have 120 seconds to answer."
Question 4	What consequences would there be, what could happen, if it was possible to read the secret thoughts of other people? Note in short feeds anything you could imagine. You have 4 minutes to answer."
Neutral Disclosure (Exchange Specific Disclosure)	
Question 5:	"How do you perceive the background image of the screen? Take your time for answering this question. When you are done, please press >>. " (Question without time limit for answering)
Question 6:	"Do you think that despite all the creativity flourishing on the Web, the Internet should be enabled to forget? What should be forgotten? Take your time for answering this question. When you are done, please press >>." (Question without time limit for answering)
Question 7:	"Do you think that creativity is important or unimportant in today's society? Why? Take your time for answering this question. When you are done, please press >>." (Question without time limit for answering)
Intimate Disclosure (Social Self-Disclosure) **Introductory Sentence: "Past research has shown that high correlations can be observed between creativity scores and the richness of personal experience descriptions. We will therefore ask you now three questions on personal experiences."**	
Question 8:	"Everybody happens to confront an embarrassing situation once in a while. Please describe a situation in which something really embarrassing happened to you! Why was it embarrassing? Take your time for answering this question. When you are done, please press >>. " (Question without time limit for
Question 9	"Throughout your life it may be that you have learned or seen something that you'd rather want to forget. Please describe what you would rather like to forget! Why do you want to forget it? Take your time for answering this question. When you are done, please press >>. " (Question without time limit

Question 10	Everybody has a personal cause he or she feels is worth fighting for (i.e. the environment, animal rights, politics, local issues…). What is it that you feel is worth fighting for? Why do you feel this way? Take your time for answering this